

AMENDMENTS TO THE CLAIMS

1. (Currently Amended) A method for growing oxide thin films on a substrate in a reactor, comprising producing the films by the Atomic Layer Epitaxy (ALE) process by feeding pulses of precursor compounds into the reactor alternately and by purging the reactor with an inert gas between the precursor pulses to provide alternate self-limiting surface reactions on the substrate, wherein the precursor compounds comprise:

at least one cyclopentadienyl compound of strontium and/or barium;

at least one volatile titanium compound; and

a reactive oxygen precursor.

2. (Previously Amended) The method according to Claim 1, wherein the oxide thin film is dielectric.

3. (Previously Amended) The method according to Claim 1, wherein said method comprises 1-10 growth cycles in succession, wherein one growth cycle comprises:

feeding of a Ba compound, a Sr compound or a volatile titanium compound;

an inert purge;

feeding a reactive oxygen precursor; and

a second inert purge.

4. (Previously Amended) The method according to Claim 1, wherein the ratio of the at least one cyclopentadienyl compound of strontium and/or barium and the at least one volatile titanium compound is 0.8-1.2.

5. (Previously Amended) The method according to Claim 1, wherein the volatile titanium compound is selected from the group consisting of a titanium halide, a titanium alkoxide, titanium nitrate ($\text{Ti}(\text{NO}_3)_4$), an alkylamino complex of titanium, a cyclopentadienyl complex of titanium, a silylamido complex of titanium, titanium dialkyldithiocarbamate, and a titanium- β -diketonate.

6. (Previously Amended) The method according to Claim 1, wherein the substrate is selected from the group consisting of a platinum (Pt), RuO_2 , IrO_2 , SrRuO_3 , LaSrCoO_3 , IrO_2/Ir , RuO_2/Pt , silica (SiO_2), silicon nitride and a silicon surface.

7 (Previously Amended) The method according to Claim 1, wherein the reactive oxygen precursor is selected from the group consisting of oxygen (O_2), water vapor, hydrogen peroxide, an aqueous solution of hydrogen peroxide, ozone, and a combination thereof.

8 (Previously Amended) The method according to Claim 1, wherein the at least one cyclopentadienyl compound of strontium and/or barium is $M(Cp)_2$ or $M(Cp)_2L_n$, where

- M is Sr or Ba,
- Cp is a fused or single cyclopentadienyl group of the form $C_5R_mH_{5-m}$, where
- m is an integer 0-5 and
- R is a hydrocarbon group, wherein the m hydrocarbon groups are either the same or different,
- the Cp groups are either the same or different,
- L_n is a neutral adduct ligand which binds to the metal by one or several of the atoms in said neutral adduct ligand.

9 (Previously Amended) The method according to Claim 1, wherein

- 10
- the at least one cyclopentadienyl compound of strontium and/or barium is $M(Cp)X$ or $M(Cp)XL_n$, where
 - M is Sr or Ba,
 - Cp is a fused or single cyclopentadienyl group $C_5R_mH_{5-m}$, where
 - m is an integer 0-5 and
 - R is a hydrocarbon group, wherein the m R's are either the same or different,
 - X is a ligand having a valence of -1, wherein X is not a cyclopentadienyl group and
 - L is a neutral adduct ligand which binds to the metal by one or several of the atoms making up said neutral adduct ligand.

10. (Previously Amended) The method according to Claim 9, wherein the cyclopentadienyl group is selected from the group consisting of cyclopentadienyl, pentamethylcyclopentadienyl, triisopropylcyclopentadienyl, indenyl, and fluorenyl.

11. (Previously Amended) The method according to Claim 8, wherein the two Cp groups are joined by a bridge.

12. (Previously Amended) The method according to Claim 11, wherein the bridge between the two Cp groups is a substituted or unsubstituted $C_1 - C_6$ carbon chain.

~~13.~~ (Previously Amended) The method according to Claim 12, wherein the carbon chain forming the bridge contains a heteroatom selected from the group consisting of silicon, nitrogen, phosphorus, selenium, and sulfur.

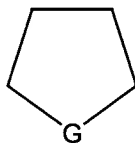
~~14.~~ (Previously Amended) The method according to Claim 9, wherein R is a substituted or unsubstituted, cyclic, linear or branched group selected from the group consisting of an alkyl, an alkenyl, an aryl, an alkylaryl, an arylalkyl, an alkoxy, a thio, an amino, a cyano and a silyl group.

~~15.~~ (Previously Amended) The method according to Claim 9, wherein the neutral adduct ligand L is selected from the group consisting of:

- (i) a hydrocarbon,
(ii) an oxygen-containing hydrocarbon,
(iii) a nitrogen-containing hydrocarbon,
(iv) a sulfur-containing hydrocarbon,
(v) a phosphorus-containing hydrocarbon,
(vi) an arsenic-containing hydrocarbon,
(vii) a selenium-containing hydrocarbon,
(viii) a tellurium-containing hydrocarbon,
and a combination thereof.

~~16.~~ (Previously Amended) The method according to Claim 9, wherein L is selected from the group consisting of:

- (a) an amine or polyamine,
(b) a bipyridine,
(c) a ligand depicted by the formula



, where G is -O-, -S-, or -NR¹-, where R¹ is hydrogen or a substituted or unsubstituted, cyclic, linear or branched group selected from the group consisting of an alkyl, an alkenyl, an aryl, an alkylaryl, an arylalkyl, an alkoxy, a thio, a cyano and a silyl group, and wherein each carbon atom of the ring according the

formula has an R¹-like substituent, wherein the substituents are either [mutually]
the same or different,

- (d) ether, and
- (e) thioether.

~~17.~~ (Previously Amended) The method according to Claim 9, wherein L is selected from the group consisting of an ether, a polyether, an amine, a polyamine, bipyridine and tetrahydrofuran.

~~18.~~ (Previously Amended) The method according to Claim 9, wherein X is selected from the group consisting of a β -ketonate, a corresponding sulfur or nitrogen compound, an alkyl, a halide, an amide, an alkoxide, a carboxylate and a Schiff base.

~~19.~~ (Previously Amended) The method according to Claim 1, wherein the producing of the film takes place at 250-300°C.

~~20.~~ (Original) The method according to Claim 3, wherein said method comprises 1-2 growth cycles.

~~21.~~ (Original) The method according to Claim 9, wherein the cyclopentadienyl group is selected from the group consisting of cyclopentadienyl, pentamethylcyclopentadienyl, triisopropylcyclopentadienyl, indenyl, and fluorenyl.

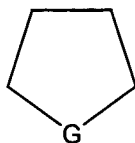
~~22.~~ (Original) The method according to Claim 9, wherein R is a substituted or unsubstituted, cyclic, linear or branched group selected from the group consisting of an alkyl, an alkenyl, an aryl, an alkylaryl, an arylalkyl, an alkoxy, a thio, an amino, a cyano and a silyl group.

~~23.~~ (Original) The method according to Claim 9, wherein the neutral adduct ligand L is selected from the group consisting of:

- (i) a hydrocarbon,
 - (ii) an oxygen-containing hydrocarbon,
 - (iii) a nitrogen-containing hydrocarbon,
 - (iv) a sulfur-containing hydrocarbon,
 - (v) a phosphorus-containing hydrocarbon,
 - (vi) an arsenic-containing hydrocarbon,
 - (vii) a selenium-containing hydrocarbon,
 - (viii) a tellurium-containing hydrocarbon,
- and a combination thereof.

~~24.~~ (Original) The method according to Claim 9, wherein L is selected from the group consisting of:

- (a) an amine or polyamine,
- (b) a bipyridine,
- (c) a ligand depicted by the formula



, where G is -O-, -S-, or -NR¹-, where R¹ is hydrogen or a substituted or unsubstituted, cyclic, linear or branched group selected from the group consisting of an alkyl, an alkenyl, an aryl, an alkylaryl, an arylalkyl, an alkoxy, a thio, a cyano and a silyl group, and wherein each carbon atom of the ring according the formula has an R¹-like substituent, wherein the substituents are either the same or different,

- (d) ether, and
- (e) thioether.

~~25.~~ (Original) The method according to Claim 19, further comprising postannealing said film at a temperature higher than a temperature at which the producing of the film takes place.

~~26.~~ (Original) The method according to Claim 25, wherein post annealing said film takes place at 500°C.

~~27.~~ (Currently Amended) A method for growing oxide thin films on a substrate in a reactor, comprising producing the films by the Atomic Layer Epitaxy (ALE) process by feeding alternating pulses of precursor compounds into the reactor and by purging the reactor with an inert gas between the precursor pulses to provide alternate self-limiting surface reactions on the substrate, wherein the precursor compounds comprise:

- at least one cyclopentadienyl compound of strontium and/or barium; and
- a reactive oxygen precursor.

28. (Previously Added) A method for growing oxide thin films on a substrate in a reactor, comprising producing the films by feeding pulses of precursor compounds into the reactor, wherein a growth cycle comprises:

feeding a first reactant pulse into the reactor, wherein the first reactant is selected from the group consisting of a cyclopentadienyl compound of strontium and a cyclopentadienyl compound of barium;

purging the first reactant from the reactor with an inert gas;

pulsing a second reactant pulse into the reactor, the second reactant comprising oxygen;

purging the second reactant from the reactor with an inert gas;

pulsing a third reactant pulse into the reactor, the third reactant comprising a volatile titanium compound; and

purging the third reactant from the reactor with an inert gas,

wherein the second reactant is pulsed between pulses of the first reactant and the third reactant.

29. (Previously Added) The method of Claim 28, wherein no more than one molecular layer is deposited onto the substrate per growth cycle.

30. (Previously Added) The method of Claim 28, wherein the first reactant is a cyclopentadienyl compound of strontium.

31. (Previously Added) The method of Claim 30, wherein the growth cycle further comprises:

pulsing a fourth reactant pulse into the reactor, the fourth reactant comprising a cyclopentadienyl compound of barium; and

purging the fourth reactant from the reactor with an inert gas.

32. (Currently Amended) The method of Claim 30, wherein the growth cycle comprises, in order, pulsing the first reactant, purging the first reactant, pulsing the second reactant, purging the second reactant, pulsing the third reactant and purging the third reactant ~~is conducted in a sequence in which the first reactant is pulsed first, the second reactant is pulsed second and the third reactant is pulsed after the second reactant.~~

33. (Currently Amended) The method of Claim 30, wherein the growth cycle comprises, in order, pulsing the third reactant, purging the third reactant, pulsing the second

~~reactant, purging the second reactant, pulsing the first reactant, purging the first reactant, pulsing the second reactant and purging the second reactant. is conducted in a sequence in which the third reactant is pulsed first, the second reactant is pulsed second, the first reactant is pulsed third, and the second reactant is pulsed fourth.~~

~~34.~~ (Previously Added) The method of Claim 28, wherein the first reactant is a cyclopentadienyl compound of barium.

~~35.~~ (Previously Added) The method of Claim 34, wherein each cycle further comprises:

pulsing a fourth reactant pulse into the reactor, the fourth reactant comprising a cyclopentadienyl compound of strontium; and

removing the fourth reactant from the reactor with an inert gas.

~~36.~~ (New) A method for growing oxide thin films on a substrate in a reactor by the Atomic Layer Epitaxy (ALE) process comprising at least three different growth cycles comprising self-limiting surface reactions on the substrate, wherein:

a first growth cycle comprises feeding a pulse of a cyclopentadienyl compound of strontium into the reactor;

purging the reactor with an inert gas;

feeding a pulse of a reactive oxygen precursor into the reactor; and

purging the reactor with an inert gas; and

a second growth cycle comprises feeding a pulse of a volatile titanium compound into the reactor;

purging the reactor with an inert gas;

feeding a pulse of a reactive oxygen precursor into the reactor; and

purging the reactor with an inert gas; and

a third growth cycle comprises feeding a pulse of a cyclopentadienyl compound of barium into the reactor;

purging the reactor with an inert gas;

feeding a pulse of a reactive oxygen precursor into the reactor; and

purging the reactor with an inert gas.

Appl. No. : 9/787,062
Filed : June 28, 2001

37. (New) The method of Claim 36, wherein said method comprises repeating the first growth cycle, the second growth cycle, or the third growth cycle from 1 to 10 times in succession.

38. (New) The method of Claim 37, wherein the ratio of the number of first growth cycles to the number of second growth cycles is 0.8 — 1.2.

39. (New) The method of Claim 37, wherein the ratio of the number of third growth cycles to the number of second growth cycles is 0.8 — 1.2.
